Scientific Inquiry

8-1 The student will demonstrate an understanding of technological design and scientific inquiry, including process skills, mathematical thinking, controlled investigative design and analysis, and problem solving.

8-1.1 Design a controlled scientific investigation.
Taxonomy Level: 6.2-C Create Procedural Knowledge

Previous/Future knowledge: In 4th grade (4-1.3), students summarized the characteristics of a simple scientific investigation that represent a fair test (including a question that identifies the problem, a prediction that indicates a possible outcome, a process that tests one manipulated variable at a time, and results that are communicated and explained). In 5th grade (5-1.3), students planned and conducted controlled scientific investigations, manipulating one variable at a time. In 7th grade, students explained the reasons for testing one independent variable at a time in a controlled scientific investigation (7-1.3) and explained the importance that repeated trials and a well-chosen sample size have with regard to the validity of a controlled scientific investigation (7-1.4).

It is essential for students to know that a *controlled scientific investigation* determines the effect of an independent variable in an experiment, when all other variables are controlled. Every controlled scientific investigation provides information. This information is called *data*. Data includes both scientific observations and inferences.

- A *scientific observation* is gained by carefully identifying and describing properties using the five senses or scientific tools and can be classified as *quantitative* or *qualitative*.
  - o Quantitative observations are observations that use numbers (amounts) or measurements (including the unit label) or observations that make relative comparisons, such as more than, all, less than, few, or none.
  - o Qualitative observations are observations that are made using only the senses and refer to specific properties.
- An *inference* is an explanation or interpretation of an observation based on prior experiences or supported by observations made in the investigation. They are not final explanations of the observation. There may be several logical inferences for a given observation. There is no way to be sure which inference best explains the observation without further investigation.

In order to design a *controlled scientific investigation* some or all of the following steps should be included:

- Identify a testable question (tests one variable at a time) that can be investigated
- Research information about the topic
- State the hypothesis as a predicted answer to the question, what may be the possible outcome of the investigation
- Design an experiment to test the hypothesis, controlling all variables except the independent variable
  - o Plan for independent and dependent variables with repeated trials
  - o Plan for factors that should be held constant (controlled variables) and/or plan for a control set-up
  - o List the materials needed to conduct the experiment
  - o List the procedures to be followed
  - o Plan for recording, organizing and analyzing data
- Conduct the experiment and record data (observations) in tables, graphs, or charts
- Analyze the data in the tables, graphs, or charts to figure out what the data means (describe the relationship between the variables)

- Compare the results to the hypothesis and write a conclusion that will support or not support the hypothesis based on the recorded data
- Communicate the results to others
    - Share conclusions and make recommendations for further study

NOTE TO TEACHER: The use of the terms manipulated variable and responding variable are no longer essential. Teachers may continue to reference these terms, but students will not be held accountable in testing. However, it is essential for students to use the terms independent variable and dependent variable.

It is also essential for students to know that science is the process of learning about the natural world by asking questions and trying to find the answers to those questions. Technology applies scientific knowledge in order to develop a solution to a problem or create a product to help meet human needs. Technology is usually developed because there is a need or a problem that needs to be solved. Steps in the technological design process include:

- *Identifying a problem or need*
    - Research and gather information on what is already known about the problem or need
- *Designing a solution or a product*
    - Generate ideas on possible solutions or products
    - Evaluate the factors that will limit or restrict the solution or product design
    - Determine the trade-offs of the solutions or products (what must be given up in order to create the solution or product)
- *Implementing the design*
    - Build and test the solution or product
    - Identify any problems with the solution or product
    - If necessary, redesign the solution or product to eliminate any problems in the design
- *Evaluating the solution or the product*
    - Determine if the solution or product solved the problem
    - Identify the pros and cons of the solution or product

The steps of the design can be communicated using descriptions, models, and drawings.

- A *scientific model* is an idea that allows us to create explanations of how the something may work. Models can be physical or mental.

It is not essential for students to develop a problem statement instead of a question for an investigation, evaluate an investigation as to how it was planned and conducted, or understand a null hypothesis. Students do not need to compare the processes of a controlled scientific investigation and the technological design process or evaluate a technological design or product on the basis of designated criteria (including cost, time, and materials).

Assessment Guidelines

The objective of this indicator is to *design* a controlled scientific investigation; therefore, the primary focus of assessment should be to devise a plan for conducting a science investigation that tests only one variable at a time. However, appropriate assessments should also require students to *recognize* steps appropriate for conducting a controlled investigation; *detect* inappropriate steps in a given investigation;

organize the results of the investigation in tables or charts; *classify* by sequencing the steps of a controlled scientific investigation; or *summarize* the steps in a controlled scientific investigation.

Scientific Inquiry

8-1 The student will demonstrate an understanding of technological design and scientific inquiry, including process skills, mathematical thinking, controlled investigative design and analysis, and problem solving.

8-1.2 Recognize the importance of a systematic process for safely and accurately conducting investigations.
Taxonomy Level: 1.1-B Remember Conceptual Knowledge

Previous/Future knowledge: In 4th grade (4-1.3), students summarized the characteristics of a simple scientific investigation that represent a fair test (including a question that identifies the problem, a prediction that indicates a possible outcome, a process that tests one manipulated variable at a time, and results that are communicated and explained). In 5th grade (5-1.3), students planned and conducted controlled scientific investigations, manipulating one variable at a time. In 7th grade, students explained the reasons for testing one independent variable at a time in a controlled scientific investigation (7-1.3) and explained the importance that repeated trials and a well-chosen sample size have with regard to the validity of a controlled scientific investigation (7-1.4).

It is essential for students to know that if the results of a scientific investigation are to be considered valid there must be a systematic process for conducting the investigation. This process must be designed safely and accurately.

A scientific investigation that is conducted accurately involves:
- Using appropriate tools safely and accurately
- Making careful measurements
- Using mathematical formulas appropriately
- Representing numbers with appropriate units of measurement where applicable
- Recording data in organized graphs, tables, and charts

Assessment Guidelines
The objective of this indicator is to *recognize* the importance of a systematic process for safely and accurately conducting investigations; therefore, the primary focus of assessment should be to remember that an investigation should be organized, safe, and accurate. However, appropriate assessments should also require students to *identify* ways to safely and accurately conduct an investigation; or *recall* conditions necessary for a valid investigation.

Scientific Inquiry

8-1 The student will demonstrate an understanding of technological design and scientific inquiry, including process skills, mathematical thinking, controlled investigative design and analysis, and problem solving.

8-1.3 Construct explanations and conclusions from interpretations of data obtained during a controlled scientific investigation.
Taxonomy Level: 6.3-B Create Conceptual Knowledge

Previous/Future knowledge: In 2nd grade (2-1.4), students inferred explanations regarding scientific observations and experiences. In 3rd grade, students predicted the outcome of a simple investigation and compare the result with the prediction (3-1.4) and inferred meaning from data communicated in graphs, tables, and diagrams (3-1.6). In 5th grade (5-1.6), students evaluated results of an investigation to formulate a valid conclusion based on evidence and communicate the findings of the evaluation in oral or written form. In 7th grade (7-1.6), students critiqued a conclusion drawn from a scientific investigation.

It is essential for students to know that once the results of an investigation are collected and recorded in appropriate graphs, tables or charts, the data should be analyzed to figure out what the data means.

Inferences are sometimes needed to help form a valid conclusion.
- An *inference* is an explanation of the data that is based on facts, but not necessarily direct observation.

The results of the investigation are then compared to the hypothesis. A *valid conclusion* can then be written and should include:
- The relationship between the independent variable and dependent variables based on the recorded data, and
- Whether the hypothesis was supported or not supported.

The conclusion is communicated to allow others to evaluate and understand the investigation.

It is not essential for students to understand or develop a null hypothesis.

Assessment Guidelines:
The objective of this indicator is to *construct* explanations and conclusions from interpretations of data obtained during a controlled scientific investigation; therefore, the primary focus of assessment should be to produce an explanation or conclusion for an investigation. However, appropriate assessments should also require students to *interpret* and *analyze* data collected in an investigation; *recognize* a valid conclusion for a given investigation; *compare* a conclusion to the appropriate investigation; *compare* the conclusion with a given hypothesis; or *select* an appropriate conclusion for a given investigation.

Scientific Inquiry

8-1 The student will demonstrate an understanding of technological design and scientific inquiry, including process skills, mathematical thinking, controlled investigative design and analysis, and problem solving.

8-1.4 Generate questions for further study on the basis of prior investigations.
Taxonomy Level: 6.1-B Create Conceptual Knowledge

Previous/Future knowledge: In 3rd grade (3-1.3), students generated questions such as "what if?" or "how?" about objects, organisms, and events in the environment and use those questions to conduct a simple scientific investigation. In 5th grade (5-1.1), students identified questions suitable for generating a hypothesis. In 7th grade, students generated questions that can be answered through scientific investigation (7-1.2) and critiqued a conclusion drawn from a scientific investigation (7-1.6).

It is essential for students to know that only questions which test one independent variable at a time can be answered through scientific investigation and data collection. The question should include the relationship between the independent and dependent variable.

Once the question is tested and data is collected and analyzed, then explanations and conclusions are made and communicated. When the conclusion is communicated it allows others to evaluate and understand the investigation. Sharing ideas may give new ideas or questions for further study. When new questions are generated, recommendations can be made on changes to the design of the investigation and may produce more reliable results.

Questions that can help decide what further investigations may be:
- Can the procedure or product be improved?
- What would happen if another independent variable were tested?
- What are you wondering now?

It is not essential for students to conduct investigations to validate further questions.

Assessment Guidelines
The objective of this indicator is to *generate* questions for further study on the basis of prior investigations; therefore, the primary focus of assessment should be to construct questions that can be tested with an investigation related to a prior investigation. However, appropriate assessments should also require students to *exemplify* questions that can be tested through scientific investigations; *critique* a conclusion; *identify* the experimental variables in the investigation to determine a new investigation design; *compare* the results of one investigation with a question for further study; *explain* the relationship between the independent and dependent variable to determine questions for further investigation; or *identify* questions that are appropriate for previously generated conclusions.

Scientific Inquiry

8-1 The student will demonstrate an understanding of technological design and scientific inquiry, including process skills, mathematical thinking, controlled investigative design and analysis, and problem solving.

8-1.5 Explain the importance of and requirements for replication of scientific investigations.
Taxonomy Level: 2.7-B Understand Conceptual Knowledge

Previous/Future knowledge: In 3rd grade (3-1.7), students explained why similar investigations might produce different results. In 4th grade (4-1.3), students summarized the characteristics of a simple scientific investigation that represent a fair test (including a question that identifies the problem, a prediction that indicates a possible outcome, a process that tests one manipulated variable at a time, and results that are communicated and explained). In 5th grade (5-1.3), students planned and conducted controlled scientific investigations, manipulating one variable at a time. In 7th grade (7-1.4), students explained the importance that repeated trials and a well-chosen sample size have with regard to the validity of a controlled scientific investigation.

It is essential for students to know that for an investigation to be scientifically valid, replication within the procedures is important to verify the results and produce valid conclusions. Scientists want to report true results; therefore, they conduct repeated trials so that patterns or trends in the data can be determined. The more data that is collected through replication, the more reliable the results. Without replication, errors in procedures or data collection may not be detected.

While gathering data during an experiment:
- Data needs to be gathered more than one time under the same conditions and with the same measurement tools.
- Repetition ensures that the experiment is *valid* and that the data is reliable.
  - Validity indicates how close the investigation is to being accurate and dependable.
  - As a result of validity, other investigations repeated the same way should produce similar results.
- When possible, measurements should be taken several times, and then the results averaged.
- Each set of repeated data is called a *trial*.

An investigation may involve a *sample*, or a portion of the total number, as a type of estimation.
- The sample is used to take a representative portion of the objects or population for research.
- A poorly chosen sample size can be unrepresentative of the whole.
- Careful observations made from a proper sample size or manipulating variables within that sample size result in information and conclusions that might apply to the whole population.

If an investigation is designed with too few trials or with an improper (too small) sample size, experimental data and the results will have invalid foundations. Reasons why a repeated investigation could produce different results may be:
- The setup of the materials was not followed properly.
- Similar procedures were not followed in the exact same way.
- Appropriate tools were not chosen to complete the investigation.
- Tools were not used properly.
- Measurements were not taken accurately.
- Different observations were collected.
- Mistakes were made when recording data such as numbers written incorrectly.

Scientific Inquiry

8-1 The student will demonstrate an understanding of technological design and scientific inquiry, including process skills, mathematical thinking, controlled investigative design and analysis, and problem solving.

Assessment Guidelines:

The objective of this indicator is to *explain* the importance of and requirements for replication of scientific investigations; therefore, the primary focus of assessment should be to construct a cause-and-effect model showing the importance of repeated trials to detect patterns and trends in data. However, appropriate assessments should also require students to *summarize* reasons why the results of an investigation may produce different results; *recall* the importance of replication; *identify* conditions necessary to collect valid data; or *exemplify* valid investigations.

Scientific Inquiry

8-1 The student will demonstrate an understanding of technological design and scientific inquiry, including process skills, mathematical thinking, controlled investigative design and analysis, and problem solving.

8-1.6 Use appropriate tools and instruments (including convex lenses, plane mirrors, color filters, prisms, and slinky springs) safely and accurately when conducting a controlled scientific investigation.
Taxonomy Level: 3.2-B Apply Conceptual Knowledge

Previous/Future knowledge: In previous grades, students used magnifiers and eyedroppers (K-1.2), rulers (1-1.2), thermometers, rain gauges, balances, and measuring cups (2-1.2), beakers, meter tapes and sticks, forceps/tweezers, tuning forks, graduated cylinders, and graduated syringes (3-1.5), a compass, an anemometer, mirrors, and a prism (4-1.2), a timing device and a 10x magnifier (5-1.4), a spring scale, beam balance, barometer, and sling psychrometer (6-1.1), and a microscope (7-1.1) safely, accurately, and appropriately. In future grades, students will use these tools when appropriate as well as learn new tools to use when collecting scientific data. A complete list of tools can be found in Appendix A of the Academic Standards.

It is essential for students to know that different tools are needed to collect different kinds of data.
- C*onvex lenses* are tools used to bend, or refract, light causing objects to be magnified.
- A *plane mirror* is a tool used to reflect light.
- A *color filter* is a tool that blocks certain wavelengths of light and transmits others.
- A *prism* is a tool that breaks light into the colors of the spectrum.
    - To use a prism appropriately, the light has to enter the prism at the correct angle to the surface in order to separate the white light.
- A *slinky spring* is a tool used to model waves.

It is essential for students to use care when handling these tools when gathering data.
- Care should be taken not to break or scratch the mirrors, lenses, or prisms.
- Color filters should not be scraped across each other as they will scratch.
- Slinky springs should not be over-stretched or twisted.

It is also essential for students to use tools from previous grade levels that are appropriate to the content of this grade level such as eyedroppers, magnifiers, rulers (measuring to millimeters), thermometers (measuring in ^{o}F and ^{o}C), beakers (measuring to milliliters), forceps/tweezers, graduated cylinders (measuring in milliliters), meter sticks and meter tapes (measuring in meters, centimeters, or millimeters), compasses, plane mirrors, prisms, timing devices (measuring in minutes or seconds), or triple beam balances (measuring to grams), tuning forks, and spring scales (measuring in newtons or grams) to gather data.

NOTE TO TEACHER: See information in previous grades regarding how to use each tool.
All temperature readings during investigations will be taken using the Celsius scale unless the data refers to weather when the Fahrenheit scale is used.

Scientific Inquiry

8-1 The student will demonstrate an understanding of technological design and scientific inquiry, including process skills, mathematical thinking, controlled investigative design and analysis, and problem solving.

It is not essential for students to use telescopes, concave or convex mirrors or concave lenses. Tools from previous grades that are not appropriate to the content of this grade level are not essential; however, these terms may be used as distracters (incorrect answer options) for assessment, for example rain gauges, measuring cups, graduated syringes, anemometers, 10X magnifiers, barometers, sling psychrometers, and microscopes. Students do not need to convert measurements from English to metric or metric to English.

Assessment Guidelines
The objective of this indicator is to *use* tools safely, accurately, and appropriately when gathering data; therefore, the primary focus of assessment should be to apply correct procedures to the use of convex lenses, plane mirrors, color filters, prisms, and slinky springs, and other tools essential to the grade level that would be needed to conduct a science investigation. However, appropriate assessments should also require students to *identify* appropriate uses for convex lenses, plane mirrors, color filters, prisms, and slinky springs; *illustrate* the appropriate tool for an investigation using pictures, diagrams, or words; *recall* how to accurately determine the measurement from the tool; or *recognize* ways to use science tools safely, accurately, and appropriately.

Scientific Inquiry

8-1 The student will demonstrate an understanding of technological design and scientific inquiry, including process skills, mathematical thinking, controlled investigative design and analysis, and problem solving.

8-1.7 Use appropriate safety procedures when conducting investigations.
Taxonomy Level: 3.2-B Apply Factual Knowledge

Previous/Future knowledge: In all grades students use appropriate safety procedures when conducting investigations that are appropriate to their grade, tools, and type of investigations.

It is essential for students to know that care should be taken when conducting a science investigation to make sure that everyone stays safe.

Safety procedures to use when conducting simple science investigations must be

- Always wear appropriate safety equipment such as goggles or an apron when conducting an investigation.
- Be careful with sharp objects and glass. Only the teacher should clean up broken glass.
- Do not put anything in the mouth unless instructed by the teacher.
- Follow all directions for completing the science investigation.
- Keep the workplace neat. Clean up when the investigation is completed.
- Practice all of the safety procedures associated with the activities or investigations conducted.
- Tell the teacher about accidents or spills right away.
- Wash hands after each activity.

It is essential for students to use tools including convex lenses, plane mirrors, color filters, prisms, and slinky springs safely and accurately, when conducting investigations.

NOTE TO TEACHER (safety while working with students):

- Teacher materials have lists of "Safety Procedures" appropriate for the suggested activities. Students should be able to describe and practice all of the safety procedures associated with the activities they conduct.
- Most simple investigations will not have any risks, as long as proper safety procedures are followed. Proper planning will help identify any potential risks and therefore eliminate any chance for student injury or harm.
- Teachers should review with students the safety procedures before doing an activity.
- Lab safety rules may be posted in the classroom and/or laboratory where students can view them. Students should be expected to follow these rules.
- A lab safety contract is recommended to notify parents/guardians that classroom science investigations will be hands-on and proper safety procedures will be expected. These contracts should be signed by the student and the parents or guardians and kept on file to protect the student, teacher, school, and school district.
- In the event of a laboratory safety violation or accident, documentation in the form of a written report should be generated. The report should be dated, kept on file, include a signed witness statement (if possible) and be submitted to an administrator.
- Materials Safety Data Sheets (MSDS) must be on file for hazardous chemicals.
- For further training in safety guidelines, you can obtain the SC Lab Safety CD or see the Lab Safety flip-chart (CD with training or flip-chart available from the SC Department of Education).

Scientific Inquiry

8-1 The student will demonstrate an understanding of technological design and scientific inquiry, including process skills, mathematical thinking, controlled investigative design and analysis, and problem solving.

It is not essential for students to go beyond safety procedures appropriate to the kinds of investigations that are conducted in an eighth grade classroom.

Assessment Guidelines:
The objective of this indicator is to *use* appropriate safety procedures when conducting investigations**;** therefore, the primary focus of assessment should be to apply correct procedures that would be needed to conduct a science investigation. However, appropriate assessments should also require students to *identify* safety procedures that are needed while conducting an investigation; or *recognize* when safety procedures are being used.